

**Carbon Capture, Utilisation and Storage:
Opportunities, challenges and pathways to Net Zero**
Thematic workshop - 17th September 2026 - Faculty of Civil and Industrial
Engineering, Sapienza University of Rome

Advancing CO₂-to-e-Fuels Technologies: beyond ECCSELLENT

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The contribution presents the experience of CNR-ITAE within the ECCSELLENT project, focusing on technologies and capabilities for CO₂ utilisation. Activities covered the research chain from catalyst and reactor design to characterisation and validation at laboratory scale (TRL4). Innovative catalytic and electrocatalytic systems were developed for converting CO₂ into methane, methanol and dimethyl ether (DME), strengthening the basis for renewable fuels and e-fuels. Activities included structured catalysts produced through additive manufacturing and robocasting, hybrid systems for one-pot DME synthesis, and non-critical raw material electrocatalysts for low-temperature CO₂ electrolysis. Advanced characterisation and catalytic testing correlated material properties, reaction pathways and performance. A key outcome was implementation of the GTL4CCU facility, integrating 3D printing, material characterisation and catalytic process validation. GTL4CCU has provided transnational access to researchers, initiating a research programme that resulted in a peer-reviewed scientific publication.

The results achieved within ECCSELLENT consolidate the expertise of the CNR-ITAE catalysis team in CO₂ conversion and alternative fuel production, while providing a basis for future developments. The transition towards the recently funded NICE-ITALY project offers the opportunity to optimise catalytic materials and develop innovative CO₂-to-e-fuels process technologies. Attention will focus on structured and additive-manufactured catalysts, process intensification and simplified reactor concepts aimed at improving efficiency and reducing CAPEX and OPEX, supporting a platform for advancing scalable and economically viable e-fuel production pathways within the broader CCUS value chain.

Keywords: *CO₂ Utilisation; e-Fuels; Catalytic Technologies*

Acknowledgments

The inputs and outcomes from ECCSELLENT (IR0000020, NextGenerationEU, PNRR M4C2 - I. 3.1) and NICE-ITALY (MUR, PN-RIC 21–27, Act. 1.1.1, DD310, 18/03/2025) are gratefully acknowledged.

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